OSHPD Technical Note for Producing Agency for Healthcare Research and Quality Inpatient Mortality Indicators, 2015 (January – September) Data

Office of Statewide Health Planning and Development

October 2016

Acknowledgements:

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Background

This Technical Note explains how the Agency for Healthcare Research and Quality (AHRQ) Inpatient Quality Indicator (IQI) software was applied to California's patient discharge data collected by the Office of Statewide Health Planning and Development (OSHPD) to generate hospital results for twelve Inpatient Mortality Indicators (IMIs) and five sub-measures for which AHRQ calculates hospital risk-adjusted mortality rates and quality ratings.

The data tables were produced by OSHPD's Healthcare Outcomes Center in the Healthcare Information Division using AHRQ Quality Indicators software Version 5.0 for SAS® with nine months (January – September) of 2015 inpatient data. Data are reported for January – September 2015 due to coding changes from ICD-9-CM to ICD-10-CM/PCS, which began October 1, 2015. Comparisons of IMIs across years should be made with caution since previous years' results are based on twelve months of data, while this analysis is based on nine months of data. OSHPD made California-specific modifications to the software which were discussed with and supported by AHRQ.

The 2015 report includes data from 321 state-licensed general acute care hospitals. Other AHRQ IQI reports can also be found on the OSHPD website including hospital-level volume and utilization measures.

How are the Inpatient Mortality Indicators useful?

The AHRQ quality indicators and related software, provided at no cost to states, use readily available patient discharge data to highlight possible differences in the quality of care provided by hospitals. These results may provide the foundation for more in-depth analyses of healthcare quality, and are intended to contribute to quality improvement efforts made by hospital administrators, clinicians, quality assurance personnel, and other stakeholders interested in healthcare quality. In addition, when the information is carefully considered along with its limitations and in conjunction with other reliable healthcare provider information, it may inform policy maker, patient, or healthcare purchaser decision making.

Do the Inpatient Mortality Indicators measure actual quality of hospital care?

These measures are *indicators* of healthcare provider quality but are not *definitive* determinations of quality. Rather, they are meant to serve as a starting point for further investigation and in-depth analyses, to prompt more extensive data scrutiny and in-depth validation of the health outcomes and associated processes of care, and to facilitate additional data validation and reliability analyses.

In addition to the IMIs, OSHPD has produced hospital-specific risk-adjusted health outcome reports (available on its website) on heart attack, community-acquired pneumonia, ischemic stroke, and heart bypass surgery, using validated risk-adjusted measures of quality with California data. These "gold-standard" reports have required many years of work to carefully construct risk models and validate the data. As a result, OSHPD has produced only a few such reports to date. Prompted by increasing demand for quality metrics and additional risk-adjusted hospital outcome reports, beginning in 2008, OSHPD began to produce and publicly report on an annual basis many of the AHRQ IMIs. It is important to note that the 2015 hospital results come with several caveats:

1. California hospital medical record data for the reported medical conditions and procedures have not been validated through medical record reabstraction (with a few exceptions) to demonstrate that patient severity-of-illness and complications are accurately and reliably coded across all hospitals

2. OSHPD has not performed detailed clinical analyses to identify the processes of patient care that may lead to improved hospital mortality rates

3. OSHPD has not performed analyses to establish that the risk models for these medical conditions and procedures, using International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM), perform well compared to gold-standard clinical models that include information such as laboratory values, vital signs, and imaging studies.

4. Because these indicators use inpatient mortality as the outcome of interest, hospitals that are less likely to transfer patients post-treatment, such as academic medical centers or safety gap hospitals, may appear to perform worse. Hospitals that regularly transfer patients to acute care or ventilator-assist facilities may appear to perform better because any deaths occurring post-transfer are not included in their outcome scores.

5. Data are reported for January – September 2015 due to coding changes from ICD-9-CM to ICD-10-CM/PCS, which began October 1, 2015. Comparisons of IMIs across years should be made with caution since previous years' results are based on 12 months of data, while this analysis is based on 9 months of data. Statewide rates, which are based on a large population are relatively stable across years, even when using 9 months of data. However, rates for hospitals may not be comparable across years.

How does AHRQ software incorporate Present On Admission (POA)?

AHRQ modified its IMI software in Version 3.2 to address a deficiency in the All Patient Refined Diagnosis Related Groups (APR-DRG) risk-adjustment algorithm employed by the indicators.[1,2,3,4] The APR-DRG algorithm is a proprietary tool of the 3M Health Information Systems Corporation. In essence, the AHRQ modification improves the risk-adjustment method by including Present On Admission (POA) data fields. The POA designation distinguishes co-morbidities or pre-existing conditions from complications or in-hospital adverse events. It improves risk-adjustment by enhancing the measurement of hospital case-mix. A prediction module had been used to impute missing POA information until the most recent release of AHRQ software Version 5.0.

In AHRQ software Version 5.0, the prediction module that estimates the prevalence of conditions as POA is removed. The software simply specifies whether or not the input data includes POA values. If POA values are missing, it's assumed the associated diagnosis is not present on admission.

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[1] Glance LG, Osler TM, Mukamel DB & Dick AW. (2008). Impact of the present-on-admission indicator on hospital quality measurement: experience with the Agency for Healthcare Research and Quality (AHRQ) Inpatient Quality Indicators. Medical Care, 46, (2), 112-119.

[2] Hughes JS, Averill RF, Goldfield NI, Gay JC, Muldoon J, McCullough E & Xiang J. (2006). Identifying potentially preventable complications using a present on admission indicator. Health Care Financing Review, 27 (3), 63-82.

[3] Romano PS & Chan BK. (2000). Risk-adjusting acute myocardial infarction mortality: are APR-DRGs the right tool? Health Services Research, 34, 1469–1489.

[4] Iezzoni LI, Ash AS, Shwartz M, Daley J, Hughes JS & Mackiernan YD. (1995). Predicting who dies depends on how severity is measured: Implications for evaluating patient outcomes. Annals of Internal Medicine, 123 (10), 763-770.

What changes did OSHPD make to the AHRQ Inpatient Quality Indicators software?

- California uses the statewide observed rate instead of the national reference rate as the benchmark when rating hospitals as “Better” or “Worse”.

- After discussions with AHRQ and University of California researchers, OSHPD staff modified the AHRQ software and implemented confidence intervals (CIs) based on the exact method. All OSHPD outcome reports to date have employed the exact method in calculating CIs. The exact method is based on the exact probability of the number of observed deaths (or a more extreme number) occurring by chance, given the number of expected deaths at a hospital. This approach differs from the normal approximation method used by AHRQ. It relies on fewer distributional assumptions and provides more conservative estimates for hospitals with relatively few expected deaths.[5] AHRQ agreed that the exact method is more appropriate for public reporting and may implement this improvement in future software releases.

- OSHPD reports only the combined unruptured open and endovascular Abdominal Aortic Aneurysm (AAA) Repair risk-adjusted mortality rate. The former OSHPD Technical Advisory Committee (TAC) recommended that OSHPD exclude rupture cases, as defined by ICD-9-CM code 441.3 when calculating hospital risk-adjusted mortality rates. Patients with aneurysm rupture have an observed mortality rate of 39% and 25% for open and endovascular repair, respectively. One of the key determinants of survival is the time that has elapsed since rupture, which is not available in the OSHPD data as a risk adjuster. AHRQ’s version stratified AAA into unruptured open and unruptured endovascular sub-categories. The number of cases for each sub-category at most hospitals may be too small to make reporting results reliable. In consultation with AHRQ, a weighted average is used to combine the two sub-categories’ mortality rates after patients’ expected mortality rates were calculated using appropriate coefficients.

How comparable are these Inpatient Mortality Indicators with other quality metrics produced by OSHPD or other organizations?

Hospital results using nine months (January – September) of 2015 OSHPD hospital data may not be comparable with quality ratings obtained using other methods, even when the clinical area of examination is the same. For example, coronary artery bypass graft (CABG) surgery risk-adjusted outcome reports issued by the OSHPD California CABG Outcomes Reporting Program (CCORP) are different from the AHRQ CABG mortality indicator in a number of important ways. Among other things, OSHPD’s CABG report:

- Is based on a different outcome, “operative mortality” (including deaths occurring after discharge but within 30 days post-operation), while AHRQ’s outcome is in-hospital mortality

- Uses clinical registry data, while AHRQ’s measure uses ICD-9-CM coded patient discharge data

[5] Luft HS, Brown BW Jr. (1993). Calculating the probability of rare events: Why settle for an approximation? Health Services Research, 28, 419-439.

- Only includes clinically similar “isolated CABG” cases, while the AHRQ measure includes more types of CABG cases
- Uses a risk model based on clinical logic, while the AHRQ risk model is empirically based
- Computes risk model coefficients using only California data, while AHRQ computes risk model coefficients from the 2012 National Inpatient Sample, developed by AHRQ’s Healthcare Cost and Utilization Project (HCUP)
- Uses audited data, while the AHRQ measure does not

The AHRQ IMIs also differ in several ways from OSHPD’s risk adjusted outcome reports that use administrative data (community-acquired pneumonia, heart attack, hip fracture repair and ischemic stroke). The OSHPD reports:

- Use a 98% confidence interval to identify hospitals whose performance differs significantly from the state average, while the AHRQ IMIs use a 95% confidence interval to identify hospital outliers
- Use 30-day mortality post-admission or post-surgery as the outcome, while the AHRQ IMIs use in-hospital mortality
- Use a risk model based on both clinical logic and empirical considerations, while the AHRQ IMI risk model is empirically based
- Compute risk model coefficients using only California data, while AHRQ’s risk model coefficients are based on the National Inpatient Sample

Finally, it is important to note some of the differences between the previous OSHPD publications of the AHRQ IMIs (2006 - 2014 data) and this report:

- Nine months of data are used in this report. Data are reported for January – September 2015 due to coding changes from ICD-9-CM to ICD-10-CM/PCS, which began October 1, 2015. Comparisons of IMIs across years should be made with caution since previous years’ results are based on 12 months of data, while this analysis is based on 9 months of data. The 2015 data may differ from previous years due to the coding change. Statewide rates, which are based on a large population are relatively stable across years, even when using nine months of data. However, rates for hospitals may not be comparable across years.
- The 2015 (January – September) report and the previous 2014 report used Version 5.0 of the AHRQ software, while the prior reports used Versions 3.2a (2006 and 2007), 4.1a (2008 and 2009), 4.4 (2010 and 2011), and 4.5 (2012 and 2013).
- Use 2012 reference population data and associated regression coefficients (2014 and 2015 reports).
- Remove the Prediction Module that estimates Present on Admission (POA) (2014 and 2015 reports). Instead the AHRQ software Version 5.0 simply applies the coefficients based on whether POA data is available in the file. If POA is not available in the data, it’s assumed the diagnosis is not present on admission.

Even when data sources are similar, differences in the data years, inclusion and exclusion criteria, the risk model, the statistical methods employed, and decisions on how to categorize performance can lead to different results when comparing a given hospital using more than one metric.

What Inpatient Mortality Indicators and which hospitals are included in the 2015 results for California hospitals?

Version 5.0 of the AHRQ software allows the calculation of 24 risk-adjusted mortality rates, including seven overall measures plus six new sub-measures related to surgical procedures, and eight overall measures plus three sub-measures related to medical conditions. Starting with Version 4.5, the AHRQ software stratifies the following three indicators into nine new sub-categories and retains the overall measures:

- Abdominal Aortic Aneurysm (AAA) Repair:
  - AAA unruptured and open
  - AAA unruptured and endovascular
  - AAA ruptured and open
  - AAA ruptured and endovascular
- Acute Stroke Mortality Rate:
  - Hemorrhagic Stroke
  - Ischemic Stroke
  - Subarachnoid Stroke
- Pancreatic Resection Mortality Rate:
  - Pancreatic Resection, Cancer
  - Pancreatic Resection, Other

As with previous OSHPD IMI reports, AAA ruptured cases are excluded. OSHPD combines unruptured open and unruptured endovascular AAA using a weighted average.

The results for three of the 15 available overall IMIs were not reported using OSHPD nine months of 2015 data for the following reasons:

- For coronary artery bypass graft (CABG) surgery, the OSHPD California CABG Outcomes Reporting Program (CCORP) already reports hospital and surgeon-level risk-adjusted mortality rates and quality ratings using data from a clinical registry expressly created for quality monitoring and reporting. This, along with other features of the data collected by CCORP, results in superior quality assessments to those obtained from the AHRQ CABG measure.

- For acute myocardial infarction (AMI), AHRQ IMIs include two measures: one includes all AMI patients and one excludes patients transferred to another acute care hospital. Upon advice from experts on its former TAC, OSHPD decided to report only the measure that includes transfer patients. Analyses show that transfer patients were, on average, less severely ill and experienced lower mortality rates than non-transfer patients, so hospitals that received large numbers of transfer patients were not disadvantaged by this decision.

- Finally, hip replacement was not included because it lacked National Quality Forum endorsement, had a very low mortality rate, and OSHPD's former TAC questioned its value as a hospital-level reported measure.

As a result, the following indicators are included in this report (more detailed definitions, including technical specifications, may be found on the AHRQ website):

Surgical Procedures:

- **Abdominal Aortic Aneurysm (AAA) Repair, unruptured** – In-hospital deaths per 100 discharges with unruptured abdominal aortic aneurysm (AAA) repair coming open and endovascular, ages 18 years and older. Excludes rupture cases (ICD-9-CM code 441.3), obstetric discharges and transfers to another hospital.
- **Carotid Endarterectomy (CEA)** – In-hospital deaths per 100 carotid endarterectomy discharges for patients ages 18 years and older. Excludes obstetric discharges and transfers to another hospital.
- **Craniotomy** – In-hospital deaths per 100 discharges with craniotomy, ages 18 years and older. Excludes patients with a principal diagnosis of head trauma, obstetric discharges, and transfers to another hospital.
- **Esophageal Resection** – In-hospital deaths per 100 discharges with esophageal resection for cancer, ages 18 years and older. Excludes obstetric discharges and transfers to another hospital.
- **Pancreatic Resection** – In-hospital deaths per 100 discharges with pancreatic resection, ages 18 years and older. Includes metrics for discharges grouped by type of diagnosis and procedure. Excludes acute pancreatitis discharges, obstetric discharges, and transfers to another hospital.
    - **Pancreatic Resection, Cancer** – Discharges with any diagnosis for pancreatic resection and pancreatic cancer.
    - **Pancreatic Resection, Other** – Discharges for all other pancreatic resection.
- **Percutaneous Coronary Intervention (PCI)** – In-hospital deaths per 100 percutaneous coronary intervention discharges for patients 40 years and older. Excludes obstetric discharges and transfers to another hospital.

Medical Conditions:

- **Acute Myocardial Infarction (AMI)** – In-hospital deaths per 100 hospital discharges with AMI as a principal diagnosis for patients ages 18 years and older. Excludes obstetric discharges, transfers to another hospital, and transfers in from another acute care hospital.

Acute Stroke – In-hospital deaths per 100 hospital discharges with acute stroke as a principal diagnosis for patients ages 18 years and older. Includes metrics for discharges grouped by type of stroke. Excludes obstetric discharges and transfers to another hospital.

  - **Acute Stroke, Hemorrhagic** – Discharges with a principal diagnosis of hemorrhagic stroke.
  - **Acute Stroke, Ischemic** – Discharges with a principal diagnosis of ischemic stroke.
  - **Acute Stroke, Subarachnoid** – Discharges with a principal diagnosis of subarachnoid stroke.

- **Gastrointestinal (GI) Hemorrhage** – In-hospital deaths per 100 hospital discharges with gastrointestinal hemorrhage as a principal diagnosis for patients age 18 years and older. Excludes obstetric discharges and transfers to another hospital.

- **Heart Failure** – In-hospital deaths per 100 hospital discharges with heart failure as a principal diagnosis for patients ages 18 years and older. Excludes obstetric discharges and transfers to another hospital.

- **Hip Fracture** – In-hospital deaths per 100 hospital discharges with hip fracture as a principal diagnosis for patients ages 65 years and older. Excludes periprosthetic fracture discharges, obstetric discharges, and transfers to another hospital.

- **Pneumonia** – In-hospital deaths per 100 hospital discharges with pneumonia as a principal diagnosis for patients ages 18 years and older. Excludes obstetric discharges and transfers to another hospital.

<u>Hospital Selection:</u>

To be included in this report, a California general acute care hospital (449 facilities total in 2015) had to have at least one patient eligible for inclusion in the IMIs (370 facilities in 2015). In addition, 38 hospitals were excluded for the following reasons:

- Twenty-three were excluded based on their categorization by the Centers for Medicare and Medicaid Services (CMS) as long-term acute care hospitals, or having an average length of stay that exceeded CMS-designated long-term acute care hospitals – these facilities treat patients with long-term acute conditions (e.g., requiring respiratory care) and have an average length of stay greater than 25 days; and

- Fifteen facilities specializing in pediatric care were excluded.

The excluded hospitals are listed in Table 1.

Table 1. Hospitals excluded from AHRQ IMI reports using 2015 OSHPD data due to provision of long-term acute care (CMS determination), hospice care, or pediatric facility designation

Type of Exclusion	Hospital Name
CMS Long-term Acute Care	Barlow Respiratory Hospital
	Central Valley Specialty Hospital
	Foothill Regional Medical Center
	Kentfield Rehabilitation & Specialty Hospital
	Kindred Hospital – Baldwin Park
	Kindred Hospital – Brea
	Kindred Hospital – La Mirada
	Kindred Hospital – Los Angeles
	Kindred Hospital – Ontario
	Kindred Hospital – Rancho
	Kindred Hospital – Riverside
	Kindred Hospital – San Diego
	Kindred Hospital – San Francisco Bay Area
	Kindred Hospital – South Bay
	Kindred Hospital – Westminster
	Los Angeles County/Rancho Los Amigos National Rehabilitation Center
	Monrovia Medical Center
	Promise Hospital of East Los Angeles – East Los Angeles Campus
	Promise Hospital of San Diego
	San Joaquin Valley Rehabilitation Hospital
	Vibra Hospital of Northern California
	Vibra Hospital of Sacramento
	Vibra Hospital of San Diego
Pediatric Facility	Children's Hospital and Research Center at Oakland
	Children's Hospital at Mission
	Children's Hospital of Los Angeles
	Children's Hospital of Orange County
	Earl and Loraine Miller Children's Hospital
	Loma Linda University Children's Hospital
	Lucile Salter Packard Children's Hospital at Stanford
	Martin Luther King Jr. – Harbor Hospital
	Rady Children's Hospital – San Diego
	Sharp Mary Birch Hospital for Women and Newborns
	Shriners Hospital for Children
	Shriners Hospital for Children Northern California
	Sutter Maternity and Surgery Center of Santa Cruz
	University of Southern California Kenneth Norris, Jr. Cancer Hospital
	Valley Children's Hospital

The final exclusion criterion relates to the volume of patients for each AHRQ IMI. The AHRQ software will not report results for a specific IMI if there were two or fewer cases in the denominator for a given hospital. Hence, hospitals with two or fewer cases in the denominator for all indicators do not appear in the report. Hospitals excluded based on this criterion are listed in Table 2. After exclusions, 321 hospitals remain and are included in this report.

Table 2. Hospitals excluded from AHRQ IMI reports using 2015 OSHPD data due to reporting fewer than three patients for all AHRQ IMIs

Catalina Island Medical Center
Central Valley General Hospital
College Hospital Costa Mesa
Fresno Surgical Hospital
Menlo Park Surgical Hospital
Miracle Mile Medical Center
Patients' Hospital of Redding
Southern Inyo Hospital
Stanislaus Surgical Hospital
Surprise Valley Community Hospital
Sutter Surgical Hospital – North Valley

In cases of hospital name changes, the discharges were attributed to the name of the hospital in use at the time the services were provided. Table 3 shows hospitals that changed names between 2014 and 2015.

Table 3. Hospitals in AHRQ IMI Reports with Name Changes between 2014 and 2015

Hospital Name in 2014	Hospital Name in 2015
1. Alta Bates Summit Medical Center – Summit Campus – Hawthorne	1. Alta Bates Summit Medical Center
2. Alta Bates Summit Medical Center – Summit Campus – Summit	2. Alta Bates Summit Medical Center – Summit Campus
3. Biggs Gridley Memorial Hospital	3. Orchard Hospital
4. Saint John's Health Center	4. Providence Saint John's Health Center
5. Queen of the Valley Hospital – Napa	5. Queen of the Valley Medical Center
6. Chapman Medical Center	6. Chapman Global Medical Center
7. Western Medical Center – Anaheim	7. Anaheim Global Medical Center
8. Coastal Communities Hospital	8. South Coast Global Medical Center
9. Western Medical Center – Santa Ana	9. Orange County Global Medical Center
10. Seneca Healthcare District	10. Seneca District Hospital
11. Sutter General Hospital	11. Sutter Medical Center, Sacramento
12. Mercy Hospital – Folsom	12. Mercy Hospital of Folsom

How were the AHRQ Inpatient Mortality Indicators calculated?

OSHPD used a modified version of the AHRQ Quality Indicators software Version 5.0 for SAS, released in April 2015. AHRQ's free software and associated documentation are available online at http://www.qualityindicators.ahrq.gov/software/SAS.aspx.

The first step in calculating rates was to transform the data elements and values of the 2015 patient discharge data into a format that can be read by the AHRQ software. Second, OSHPD specified the number of diagnoses and procedures available in the data set. Third, All Patient Refined Diagnosis Related Groups (APR-DRG) “groupers” and associated “risk of mortality” categories were added to each patient record by running the 3M Health Information Systems Corporation software licensed to AHRQ. Finally, the coefficients used in the risk-adjustment process (described below), as well as population rates, were constructed based on the 2012 National Inpatient Sample (NIS) compiled by the AHRQ Healthcare Cost and Utilization Project (HCUP). The coefficients from the 2012 NIS were used for the 2015 report. Once the data were transformed and the options were set, the software was run to automatically calculate the rates described below.

Standardizing the Patient Data

California hospitals electronically submit inpatient data including patient age, length of stay, gender, race, ICD-9-CM codes, and related information to OSHPD. The OSHPD Healthcare Information Division Patient Data Section then applies thousands of quality control automated “edits” using a custom software program that flags data values submitted by hospitals to OSHPD as invalid or likely wrong. If certain thresholds are reached, hospitals are contacted and asked to review the data and make any necessary changes. Once the data have been finalized, OSHPD researchers use SAS software to transform the data elements to conform to the standards specified in the AHRQ documentation. These are the same standards that AHRQ applies to the State Inpatient Database and the NIS, collected from most states and maintained by the federal government.

Calculation of Observed Rates

The AHRQ IMI software produces numerators, denominators, observed rates, expected rates, risk-adjusted rates, and additional information to evaluate confidence intervals and reliability of the indicators. The 2015 report produced by OSHPD focused on risk-adjusted rates and confidence intervals for California acute care hospitals. Terminology and methodology used for determining these rates are described below to help explain the process of generating risk-adjusted rates.

Numerator – The number of inpatient deaths that occurred in a specific denominator population. For example, the number of patients who died within the hospital after being admitted for heart failure (after excluding patient records based on the denominator definition).

Denominator – For each IMI, expert clinicians used ICD-9-CM codes to select patient discharge records with diagnoses or procedures that indicate a particular condition or procedure. For example, heart failure is a complex condition that can be defined by numerous diagnoses, thus clinicians select only the specific codes that represent the intended concept of the indicator. From the initial cohorts of patients, some records were excluded. For example, patients that were transferred to another short-term hospital were excluded for some cohorts (see AHRQ documentation for additional exclusion criteria). In addition, maternal patients were excluded when constructing most of the indicators. In sum, the denominators represent the total number of patients for specific conditions or procedures that are “at risk” of dying during their hospital stay.

Observed Rates – An observed mortality rate is defined as the number of patient deaths that occur within a specified group of patients admitted to the hospital for a medical condition or surgical procedure.

Calculation of Expected Deaths at Each Hospital

The purpose of statistical risk adjustment is to provide an equitable comparison between hospitals by accounting for hospitals that treat sicker patients versus those that treat healthier ones. To make comparisons fair, it is necessary to hold the patient "case mix" of hospitals constant by adjusting for the illness severity of patients. To create risk-adjusted rates, the first step is to estimate how many people would be expected to die in a particular hospital if they had a mix of patients that was comparable to the average hospital from the reference population (the 2015 California observed rates for this report). Although the particular methods require technical expertise, the process of generating expected rates is straightforward.

Step 1: Select Risk Factors to Predict Inpatient Death

Consulting with medical experts and statisticians, AHRQ chose risk factors that predicted hospital inpatient death. For most of the IMIs, the risk factors include patient age, gender, procedure/condition category, and a risk-of-mortality score associated with each procedure/condition category. To assign each patient into a procedure/condition category, AHRQ selected a proprietary tool from the 3M Health Information Systems Corporation—the All Patient Refined Diagnosis Related Groups (APR-DRGs). The APR-DRG system works with hospital administrative data and provides a way to categorize patients into procedure/condition groups, and, given membership to that group, to estimate the severity of patients' diseases and the likelihood that they will die in the hospital. These estimates are calculated by looking at patient age, principal diagnosis, and secondary diagnoses to assign each patient into one of four categories (low, moderate, high, or very high) for disease severity and risk of mortality.

OSHPD staff used the AHRQ-licensed software from 3M to apply the APR-DRG fields to the standardized California hospital inpatient data described above. This creates the base APR-DRG category and the associated "risk of mortality" fields in the dataset.

Beginning with AHRQ Version 3.1, POA has been incorporated in the AHRQ Quality Indicator risk-adjustment methodology. It provides a means of distinguishing pre-existing co-morbidities from complications. In Version 5.0, the software uses the actual value of POA and does not impute POA using a prediction module. Missing POA data values are treated as if they were coded not present on admission.

Step 2: Create Multivariate Model to Predict Inpatient Death

Logistic regression models were built by AHRQ to predict patient's probability of death. The logistic regression models use a General Estimating Equations (GEE) approach to account for within-hospital correlation when possible. If the GEE model does not converge, a logistic regression model is used. Each indicator has a set of covariates identified in a logistic regression model. Its risk adjustment parameters are estimated based on population data. AHRQ has published a more detailed summary of how these models work on its website (http://www.qualityindicators.ahrq.gov/modules/Default.aspx).

Step 3: Apply Model Coefficients to California Data to Calculate Predicted Probability of Death

The software provided by AHRQ includes the coefficients for each IMI that were created by the multivariate model on the 2012 NIS. To enable custom reports on new samples of data, the AHRQ software identifies which risk factor is present for each patient. Then the coefficients are appropriately applied to the California data so that a predicted probability of death is assigned to each patient. The predicted probability calculated from this step is also referred to as the "direct predicted rate."

Step 4: Estimate Expected Deaths at Each Hospital

The first three steps assign a probability of death for each patient record. To obtain the expected number of deaths for each hospital, the software simply adds up all of the patient-level probabilities for each facility.

<u>Calculation of Risk-Adjusted Rates</u>

With observed and expected mortality rates available for each hospital, it is then possible to construct risk-adjusted rates. While it is sufficient to compare the difference between observed and expected rates to assess higher and lower quality, adding a reference population makes it easier to compare rates. The risk-adjusted (or indirectly standardized) death rate at a hospital equals the State Observed Rate, multiplied by the ratio of the number of observed deaths to the number of expected deaths at that hospital (Observed Cases/Expected Case or "O/E" ratio). The O/E ratio provides a transparent and easy-to-understand assessment of that hospital's performance. A ratio that is less than one indicates there were fewer actual deaths than expected (a good result) while a ratio greater than one indicates that there were more deaths than would be expected given the level of risk in the patient mix.

<u>Calculation of Statistical Outliers</u>

For each IMI, hospitals were rated as "better than expected" if their risk-adjusted death rates were significantly lower than the statewide observed rate. They were rated as "worse than expected" if their rates were significantly higher than the statewide risk-adjusted rate of the particular IMI. To calculate outlier ratings, OSHPD used the 95% upper and lower confidence intervals. The Version 5.0 of the AHRQ software calculates confidence intervals (CI) using the normal approximation as follows:

> Lower CI = "Hospital A" risk-adjusted rate – (1.96 * Standard Error)
> Upper CI = "Hospital A" risk-adjusted rate + (1.96 * Standard Error)

The standard error for the risk-adjusted rate (for each hospital) is based on the following formula:

The Root Mean Squared Error (RMSE) for each hospital is:

> RMSE = square root ("Hospital A" risk-adjusted rate * (1 – "Hospital A" risk-adjusted rate))

The Standard Error is:

> SE = RMSE / square root ("Hospital A" denominator)

For example:

If “Hospital A” had a rate of 0.20 and a denominator of 500:

Lower CI = 0.20 – 1.96 * sqrt [(0.20 * (1 – 0.20)) / 500]
Upper CI = 0.20 + 1.96 * sqrt [(0.20 * (1 – 0.20)) / 500]

OSHPD employed the exact method in calculating confidence intervals (CIs) to provide more conservative estimates for hospitals with relatively few expected deaths.

To identify statistical outliers, OSHPD compared hospital risk-adjusted rates to the upper and lower CIs. If a hospital’s upper CI is less than the statewide observed rate, it is designated as performing “better” than the average hospital. If a hospital’s lower CI is greater than the state rate, it is designated as performing “worse” than the average hospital. Using this approach, one can be 95% confident that a rating of “better than expected” or “worse than expected” was not obtained by chance. Smaller hospitals, however, have less statistical power to be classified as performance outliers, especially significantly “better” than the statewide rate. Their risk-adjusted death rates would have to be much higher or lower than a high-volume hospital’s for them to be significantly different from the state average. Conversely, a large hospital with more patients for a particular indicator may be identified as significantly different even when its death rate differs only moderately from the state average.